Sturgeon and Lamprey Information Issues

Lower Willamette River NPL Site Response & Restoration

Purpose

Recognizing our interrelated responsibilities under CERCLA, the response agencies, the natural resource trustees, and the Lower Willamette Group (LWG) have endeavored to identify and resolve remaining information shortfalls and knowledge gaps that are impeding comprehensive response and restoration decision making at the Portland Harbor National Priorities List Site. The value of coordination of investigations such that our respective CERCLA response and restoration responsibilities can be simultaneously satisfied was exemplified by the chinook spring-run young of the year effort completed last spring, generally agreed upon as a "success." The third, and possibly final, round of data collection will soon be underway for the Site.

The ultimate goal of this data gathering effort should be to complete assembly of an adequate information set which will be necessary to support risk management decisions and to complement the trustees' injury and restoration scaling decisions. This approach will also allow universal settlement of hazardous substance release liabilities. The optimum approach to finally resolving these issues may be to work with U.S. Environmental Protection Agency (EPA), Oregon Department of Environmental Quality (DEQ) and the interested members of the LWG to develop and implement such a framework on an expedited timeline.

The trustees earnestly believe that an efficient, adaptable framework that addresses the most important aspects of the information shortfalls must be developed and we are currently committed to doing so. Ideally, a phased "if, then, else …" structure could be agreed upon that would logically select which modules of the co-designed framework to implement. Resolution of questions by means other than *de novo* data gathering could also be considered to resolve items.

Background

Some information on multiple tissue contaminants of potential environmental concern (COPEC) concentrations for Pacific lamprey and white sturgeon have been developed in the last few years that seemingly indicate non-trivial exposure to some COPECs in the sampled areas, but interpretation of risk to the fish posed by that exposure is highly uncertain.

Of all groups of fish, lamprey and sturgeon are among the most poorly understood in terms of physiology and hazardous substance toxicity. Sturgeons (Acipenseriformes) are the last extant representatives of a group of fishes that diverged from other Osteichthyes, via a probable common piscine ancestor

shared during the Pennsylvanian to Cretaceous timeframe. Lamprey, Class Cephalaspidomorphi, superclass Agnatha originated in the middle Ordovician and represent an extremely primitive, though highly successful fish. The sturgeon's degree of phylogenetic divergence from the osteichthian fishes typically used to establish toxicological reference values has made agreement on selection of surrogate species for risk or injury assessment problematic. The degree of phylogenetic divergence of the agnathan lamprey is even greater than that for sturgeon.

Concerns about relative sensitivity over so large a range of phylogenetic distance means much of the available toxicity reference value (TRV) information for fish has a higher degree of uncertainty than is generally recommended in risk assessment guidance and so TRVs remain an unresolved issue. There are several interrelated issues including details of exposure and physiological sensitivity that remain unresolved regarding these highly valuable and exceptionally unique ecological receptors/resources.

In trying to focus and refine remaining information needs and inform a timely technical conversation among all the major parties with interests in the Site, the trustees have compiled this generally comprehensive summation of remaining issues associated with two unique and highly valued Site receptors. Also provided are 'starting point' methodological suggestions as to how appropriate information might be obtained. Remaining information needs may be addressable in a similar fashion later.

This appendix is a conceptual overview of a suite of lamprey and sturgeon studies that the trustee representatives have determined could provide useful information for hazardous substance risk management and/or for the process of determining injuries, scaling injuries, and restoration decision making.

White Sturgeon (Acipenser transmontanus)

Sturgeons, a bottom-dwelling fish that feeds largely on detritus, clams and other bottom-dwelling biota, have direct contact with bedded sediment and are very long-lived (up to 100 years). Several contaminants tissue concentrations can continue to increase throughout the life of long-lived fish species and may accumulate to levels of potential concern. The interrelated issues of exposure and physiological sensitivity appear to remain unresolved regarding this valuable and somewhat unique ecological receptor.

What is the effect of exposure to selected site COPECs on survival and growth of juvenile sturgeon (<107 cm)? What level of accumulation (exposure) to selected site COPECs on the growth, reproductive success and survivorship of breeding size sturgeon (> 150 cm)?

a. Suggestion: Conduct analysis of a limited suite of analytes in tissue plugs on adults and in whole body tissue and stomach contents on

pre-breeding individuals, and conduct a health examination on individual sturgeon following the U.S. Geological Survey, Biological Evaluation of Status and Trends (BEST)-derived methods. This design would allow for intercomparisons between adult and pre-breeding sturgeon tissues (to determine adult sturgeon carry a greater body burden than younger sturgeon), allow for comparisons to sturgeon tissues collected in other studies, and provide an inexpensive and quick method for remedial success monitoring. The Lower Willamette River (LWR) 'population' would also be compared to individuals collected from a reference 'population.'

b. Suggestion: Do adult sturgeon captured in the Site carry a greater body burden of COPEC than younger sturgeon? Sample & compare tissue concentrations.

c. Suggestion: Determine whether COPEC levels in adult sturgeon are toxic by comparing tissue concentration values to TRVs (need TRVs to interpret tissue values)

What is the area of use, site fidelity and duration of exposure of reproductively mature and immature sturgeon?

a. Suggestion: Attach radio-tags/use acoustic tracking to monitor sturgeon movements in and out of the Site to answer questions of site use and more thoroughly address risk in a timely fashion

b. Suggestion: Combine this tagging study with on-going studies in the lower Columbia River to help reduce costs and use existing monitoring stations and field crews

What is the direct toxicity of site related COPECs to reproductively mature and immature sturgeon?

a. Suggestion: Conduct toxicity studies, with a refined group of COPECs

    a. that have distinct endpoints measurable in a toxicity test, and

    b. that have been used successfully in toxicity testing of other fish.

b. Suggestion: Identify non-bioaccumulative contaminants that are sturgeon may be exposed to and identify lab that conduct appropriate toxicity tests.

c. Suggestion: Compare bioaccumulative contaminant tissue concentrations to "sensitivity calibrated" literature based reproductive TRVs (as we can't raise sturgeon and test them for years through food and/or water exposures).

Does maternal transfer of contaminants adversely affect developing embryos and fry?

a. Suggestion: Capture gravid females at reference locations. Develop a method to deliver various doses of COPECs to achieve standardized exposure concentrations in eggs. Assess egg survival and growth of hatchlings compared to control & reference samples.

Pacific Lamprey (Entosphenus tridentatus)

Pacific lamprey is an anadromous fish with a complex life history. Juvenile lamprey in the ammocoete stage are filter feeders and can spend up to seven years burrowing in sediment and drifting down tributary reaches, eventually metamorphosing into the macropthalmia stage in preparation for entry into salt water and a parasitic marine life. Juvenile lamprey undergoing metamorphosis are likely sensitive to contaminant exposure due to the hormonal changes and in preparation for the osmotic challenges the organisms must endure. Other organisms such as amphibians and salmonids have been shown to be very sensitive to contaminants during these transition periods. In addition, juvenile lamprey accumulate lipid just prior to the metamorphosis and do not feed during this time, relying on the stored lipids to sustain energy requirements.

After spending time in the ocean as a parasite feeding on fish and marine mammals, adult lamprey return to freshwater to spawn. Some adult lamprey return to the spawning areas after passing through the lower Columbia and lower Willamette Rivers. Recent data indicate that some adult lamprey might just not pass through the LWR but could spend many months, including overwintering, in freshwater prior to reaching their spawning areas. Adult lamprey can be exposed to dissolved contaminants through the skin and gills during their upriver migration, especially while in the LWR. Adult lamprey do not feed while in freshwater, but rely on their large lipid stores for energy. During lipid metabolism, re-exposure of target organs may occur, and maternal transfer of contaminants in adult females could threaten survival of eggs and development and growth of embryos.

Juvenile lampreys have been captured in the LWR in the ammocoete stage and at various stages of metamorphosis. Therefore, juvenile lamprey could be accumulating lipophilic contaminants while feeding in the harbor area and become exposed to these contaminants as lipid stores are used up during a sensitive transition period to another life stage (within the harbor or downstream of the harbor). The ammocoetes could also be exposed to dissolved contaminants during this period within the harbor, either during the filter-feeding stage or during a non-feeding transition period.

Are juvenile lamprey exposed to and accumulate COPECs in the Site?

a. Suggestion: Identify suitable habitat for ammocoetes and macropthalmia (young lamprey that have completed metamorphosis) based on sediment profile index data and sediment grain size and collect ammocoetes and macropthalmia of various sizes using specialized electroshock-dredging techniques.

b. Suggestion: Determine by chemical analysis, baseline COPEC levels these ammocoetes and macropthalmia and compare values to reference areas.

c. Suggestion: Determine the magnitude at which COPEC concentrations in juvenile lamprey may exceed TRVs derived from the most sensitive fish species.

What is the direct toxicity of site-related COPECs to juvenile lamprey?

a. Suggestion: Select a representative juvenile stage of lamprey and collect test organisms from a clean site. Conduct range-finding toxicity studies followed by more intensive toxicity tests (if necessary) with a refined group of COPECs

    a. that have distinct endpoints measurable in a toxicity test, and

    b. that have been used successfully in toxicity testing of other fish.

b. Suggestion: Compare bioaccumulative contaminant tissue concentrations to "sensitivity calibrated" literature based reproductive TRVs.

Which life stage of lamprey is the most sensitive to contaminants?

a. Suggestion: Calibrating bioassays using selected life history stages with exposure to COPECs in tissue, water and sediment. The design could be optimized by adding a tissue residue component to the study design. Attempt to tie lamprey into rich toxicology literature for osteichthian fish.

What is the risk to adult, juvenile and metamorphosing lamprey of exposure to site contaminants?

a. Suggestion: Capture gravid females at two locations: (1) Willamette Falls, and (2) reference. Strip these females of their eggs, and rear them in the lab under identical conditions. Measure and compare mortality rate of eggs, and growth and mortality rate of hatchings.

b. Suggestion: Compare results to egg TRVs for other fish species, assuming that egg TRVs developed for other fish are protective of lamprey.

Does maternal transfer of contaminants adversely affect developing embryos and ammocoetes?

b. Suggestion: Capture gravid females at reference locations. Develop a method to deliver various doses of COPECs to achieve standardized exposure concentrations in eggs. Assess egg survival and ammocoete growth compared to control & reference samples.

What is Accumulation of COPECs in juveniles in the Site?

a. Suggestion: Identify suitable habitat for ammocoetes and macropthalmia (young lamprey that have completed metamorphosis) based on sediment profile index data and sediment grain size and collect ammocoetes and macropthalmia of various sizes.

b. Suggestion: Determine by chemical analysis, baseline COPEC levels these ammocoetes and macropthalmia.

What are adult accumulation levels and effects of lipid metabolism COPEC Concentrations and target organ availability?

a. Suggestion: Sample: beginning and end of the lamprey harvest season (early June- late July).

b. Suggestion: Use mean levels of COPECs in the upstream sample will help elucidate baseline human health risk from adult lamprey consumption.

c. Suggestion: Determine the difference in mean levels of each COPEC between the early season (IIA above) and late season samples reflects the effect of lipid metabolism on whole body concentrations of COPECs.

d. Suggestion: Determine the extent to which the concentration of a specific COPEC will increase or decrease between early and late season depends

e. Suggestion: Determine the extent to which lamprey can or cannot excrete and/or metabolize the COPEC as lipid is metabolized, i.e., the extent to which the COPEC

Can we develop refine exposure assumptions for the Site?

Adult lampreys pass through the Site during their spawning migration; however, the duration of exposure within the Site poorly understood.

a. Suggestion: Radiotransmitter tag fish and construct time-geo-referenced position record. Opportunities exist to piggy back this effort on ODFW tracking effort (salmon?)

b. Suggestion: Refine exposure assumptions via average rate of migration through and total residence time.

c. Suggestion: Inferences about habitat use and preference locations.

What are the effects of contaminant avoidance and olfaction impairment in adults?

Some fish can detect and avoid some, but not other contaminants. Further, some contaminants interfere with olfactory function, including their ability to locate their natal spawning grounds by olfactory cues. Some contaminants have the ability to interfere with olfactory function and could interfere with adult lamprey's ability to locate their spawning grounds and reproduce.

a. Suggestion: Conduct laboratory trials with adult lamprey to assess whether COPECs can be detected and avoided by adult lamprey.

b. Suggestion: Conduct laboratory trials with adult lamprey to assess various levels of site COPECs that interfere with the olfaction in adult lamprey.